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PARASITE OF MALARIA IN THE
FEVERS OF SIERRA LEONE

BY

SURGEON-CAPTAIN C. W. DUGGAN, M.B.

ARMY MEDICAL STAFF

(COMMUNICATED BY DR. GEORGE THIN)

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THE well-known virulence of the malarial fevers which prevail on the west coast of Africa continues until the present time with unabated force. Europeans and natives are alike subject to their ravages, although they exact a higher tribute from the former. When not fatal such fevers often render life a burden for many years, whilst a few fortunate individuals seem, at least for a long time, to be proof against their attacks.

Sierra Leone (where the following observations were made) is a highly mountainous district, both its valleys and mountains being covered with a very luxuriant vegetation. The soil consists of a porous red earth, which appears to play an important part in the causation of malaria.

The river Roquette, which has a large volume of water, opens into the sea at the native town of Freetown, half a

mile inland from which are stationed the principal barracks, which are built on a hill about 600 feet high. Mangrove swamps exist near Freetown, but are covered by the tide. The average daily temperature is about 80° F., and the annual rainfall about 150 inches. The rainy season lasts from May till October. There is no cold season. The heat is trying from the large amount of moisture present in the atmosphere.

My experience in this disease was gained during a residence of two years at Sierra Leone, where I was occupied in attending the officers and men of Her Majesty's West India Regiment. The two years were not consecutive, being separated by the usual interval of one year. As I made it my practice, during both periods of residence, to examine the blood of all the fever patients with whom I came in contact, I am within the mark when I state that I must have examined the blood of at least 400 different patients suffering from fever. I have taken notes of the observations in 50 cases. The cases which I shall relate in this paper are selected from the 50, and are fair average examples of all the others. During part of the time I used a Swift's $\frac{1}{12}$ in. oil immersion, and for the rest of the time a Zeiss $\frac{1}{12}$. Both these objectives showed the parasite in the fresh blood sufficiently well. Examination of the blood was discontinued after the patients left the hospital. In many cases they had suffered from fever for some time before admission. They were detained in hospital until free from fever. The average duration of the stay in hospital of the fever cases in Sierra Leone which I observed was about a week. In most cases that short period was sufficient to cure the fever for the time being. In many instances the fever symptoms disappeared within a day, sometimes to reappear a few days afterwards; but sometimes the temperature did not again rise.

The first attack of malarial fever experienced by newcomers is usually of the quotidian remittent type. The onset is often sudden, and is frequently unattended by rigors.

The symptoms in an ordinary attack are as follows. The patient complains of headache, and pains in the trunk and limbs, and occasionally of severe giddiness. The tongue is furred, and there is frequently nausea with very distressing bilious vomiting. Constipation is common, but in some cases I have seen severe diarrhœa. Occasionally there is no disturbance of the bowels whatever. A dull aching, and sometimes an acute pain is present in the hepatic region. Jaundice is rare. The spleen is not enlarged to an appreciable extent. The temperature on the first day ranges between 103° F. and 105° F.; on the second morning there is usually a remission of two to three degrees, and towards evening a rise to 105° F.; on the third morning there is again a remission of several degrees, and in the evening another exacerbation; on the fourth morning the temperature is often normal, and in the evening there may be again a slight exacerbation— 100° F. to 101° F.; on the fifth morning the temperature is normal, and as a rule remains so.

Quinine is so generally given in these cases that the above account of the course of the symptoms necessarily refers to cases that have been treated by the drug, but there is reason to believe that even without quinine the course of the fever would be somewhat similar. When I myself suffered from the fever, the quinine which I took was at once rejected by vomiting to such an extent that I do not think that any of it was retained; certainly none for the first three or four days, notwithstanding which I had a remission each morning.

The skin, which is at first hot and dry, soon becomes covered with a profuse perspiration, although for some days there is no corresponding fall of temperature.

Delirium, if present, is generally slight, but for several nights there are most distressing dreams, and a tendency to magnify the most trifling occurrences. The symptoms are, in many respects, similar to those which are characteristic of delirium tremens.

The pulse and respiration rates are directly propor-

tional to the temperature. The urine frequently contains bile.

About the fourth day of the fever the tongue begins to clean, and there is a desire for solid food. The other evidences of fever disappear, and in a week the patient feels quite well.

Subsequent attacks occur at irregular intervals, and often last only a few hours. In many of them the three stages of an ague fit are present. In the men of the West India Regiment, recruited in the West Indies, and consisting of negroes and a large proportion of mulattos, malarial fever, except in some bad cases, does not continue for many hours, but the admissions to hospital are frequent, and there are usually several attacks during each admission.

Pyrexia, in a few cases, lasts for weeks, the temperature being about 101° F., and often remitting a degree in the morning. One such case ended fatally in the fourth week, although the patient was invalided to Grand Canary in the second week of the disease. This result was chiefly due to the debilitating effects of a long arduous expedition after two years' residence in Sierra Leone.

Dr. Prout ('Lancet,' 1891, vol. ii, p. 226) gives an account of the malarial fevers observed on the Gold Coast. The symptoms which he describes in these fevers are essentially the same as those which I have given as generally attending the fevers at Sierra Leone. It will be noticed that I have not laid the same stress on enlargement and tenderness of the spleen which Dr. Prout has done; although in chronic cases enlargement of the spleen is common, in many acute cases which I observed of a short duration I did not notice much tenderness or enlargement of that organ.

Fatal cases.—In the fatal cases I have seen, death with one exception was preceded by several hours or days of unconsciousness. In one case there were hysterical fits for five hours before death, the patient struggling violently with his attendants, whistling, singing, shouting, and

breathing about sixty per minute ; these fits were preceded by two days' delirium, and at no time during this period was there any return of consciousness.

The temperature varies considerably ; in some it runs up to 107° or 108° F. According to my experience this is most likely to occur in new-comers ; but in those who have undergone considerable hardship in the colony, or have been resident a long time, the temperature shortly before death may be normal, or not more than two or three degrees above normal.

Death occurred in one case which I observed from hæmorrhage from the bowels. The hæmorrhage occurred suddenly, and continued till he died, about nine hours later. In several cases in which the fever was pursuing a mild course serious symptoms set in suddenly and unexpectedly, and the case terminated fatally after a shorter or longer period. During the earlier and milder stages of these attacks there was no symptom which led me to expect a fatal result.

In examining the blood, fresh and dried preparations were made in the usual way. Specimens were stained with eosin and methylene blue, or Ehrlich's hæmatoxylin, and in some cases a drop of very dilute solution of methylene blue was added to fresh blood. Parasites were always found during the whole of the attack and for several days after.

My examinations were made from 10 a.m. till 2 p.m., and again from 4.30 p.m. to 6.30 p.m. As parasites were found in every case at these times whilst the fever lasted, it is presumable that they would have been found had the examinations been made at other times of the day, and the inference may be drawn that parasites in these fevers can be found in blood taken from the finger at any time during the course of the disease.

With the exception of an account of the histology of the tissues in a fatal case of pernicious malaria at Sierra Leone by Dr. Thin, which is published in vol. lxxix of the 'Medico-Chirurgical Transactions,' nothing appears to

have been published regarding the parasite of malaria which occurs in that part of the west coast.

I have only succeeded in distinguishing one kind of parasite, which was, in a proportion of cases, accompanied or followed by the so-called crescent forms. I exclude a case of tertian fever to be subsequently referred to. In the unpigmented stage this parasite appears as an extremely small bright speck on the surface of the red corpuscle, from which it cannot be detached by any ordinary pressure. At first it is constantly changing its shape, at one time spherical, and at another throwing out processes which, remaining visible for a number of seconds, are gradually withdrawn, and an irregular shape is maintained for some time. Instead of this amœboid motion the parasite every now and then suddenly contracts to half its size, and just as quickly resumes its original condition. This movement is repeated a number of times. Finally, after several hours the parasite assumes a spherical or slightly irregular form, in the centre of which what appears to be a small portion of the red cell is visible. The central portion stains with methylene blue in the youngest parasites. At a slightly more advanced stage only the periphery of the parasite takes on a blue stain, and one or two deeply stained nucleoli can be easily made out. A more advanced stage is evident in a few cases where the whole parasite containing a mass of pigment stains blue. In most cases there is only one parasite attached to a red blood-cell. The largest number I have seen occupying one red cell is five, all of which were at the same stage of development.

In some specimens stained with eosin and methylene blue I have observed two somewhat conical-shaped parasites united by their bases, each parasite having a nucleolus and with only the periphery stained blue.

I often observed the same parasites for hours continuously, and although the movements continued active the development of the parasite never progressed, as it presumably would have done if the blood had not been removed from the body.

The affected red cells did not seem to be altered as regards colour, size, and shape.

I never saw the so-called brassy-red corpuscle (the "*ottonati*" of the Italian writers), although I looked carefully for it.

In the early stage of pigmentation the parasite has enlarged slightly, and contains several minute grains of pigment. The sporulating stage was never observed by me in the peripheral blood. It is best seen, according to my observations, in the fresh blood removed from a small vessel on the surface of the brain soon after death. The effect of the parasite on the movement of the affected cells is very evident in such a case, for while the normal red cells were influenced by currents in the field of the microscope, those containing the parasite were perfectly motionless. It was then seen that sporulation occurs while the parasite does not occupy more than a third of the red cell. The spores became indistinct so soon after the death of the patient that I found it difficult to count them, but in one case in which I succeeded in doing so I saw five spores surrounding a small central block of pigment.

Crescents were found in varying numbers in most of the cases. In length they varied from about 8 to 12 mm., and in breadth from 3 to 5 mm. In most cases the pigment is massed near the centre of the crescent. In the larger crescents the pigment appears to lie in a differentiated structure in the centre, and in one crescent I saw the pigment lying beside this structure. The crescent is often seen in close relation to several blood-corpuscles, from which it can be readily detached by pressure. It does not appear to be capable of independent movement.

I have on several occasions seen an active movement in the central pigment of the crescent body, the minute spheres and rods of which it is composed moving rapidly from one clear space to another in the central portion of the parasite. This movement sometimes continued for several hours. Mannaberg states that the concentrated

pigment is invariably quiescent (New Sydenham Society translation, p. 284).

I have never observed the crescent change into a spherical form with the formation of flagella. In the light of the information contained in the letter to the 'Lancet' by Dr. Marshall (October 24th, 1896) this is probably owing to the moist warm atmosphere in which the specimens were examined, which would tend to keep the blood-plasma unaltered for a considerable length of time. I never saw flagella, although the crescents were often under observation for many hours. A number of the spherical forms still retained the outline of the red cell in which they had developed, as was signified by the delicate envelope of red blood-cell substance which surrounded them. The contained pigment was sometimes in the form of comparatively large spheres, several of which became detached from the others, and moved round the interior just within the outline of the red cell.

Dr. Prout, in the paper already referred to, gives the results of microscopical observations made by him in ten cases. Examination of the blood was made in ten cases, partly European, partly native, including two cases of bilious remittent, one of hæmoglobinuria, the rest mild intermittent. Only fresh unstained specimens were examined, taken generally when the temperature was rising, and on one or two occasions at different intervals during the attack. In eight cases there were distinct changes in the red cells, divided by Dr. Prout into five kinds :—1st. Brightly refracting rod-like bodies occurred in three cases, and in one of them were very numerous. They varied in number and size, possessed a certain movement described as pulsatile, and occasionally a slight alteration of their position in the corpuscle occurred. 2nd. Brightly refracting round spots of different sizes, sometimes combined with the rod forms. 3rd. Large circular bodies like vacuoles, in the centre, or to the side of the corpuscle, sometimes with rods. 4th. Irregular bodies which may be regarded as transition stages between the above forms. 5th. In three cases

bodies like a tadpole or spermatozoon with an oval head, and tapering filament attached. Like the other bodies they were translucent and possessed limited movement. They are not so common as the others, four being the largest number in one preparation. None of these bodies contained pigment. Pigmented bodies were seen in five cases. 1st. Small corpuscles about the size of a leucocyte with dark brown pigment granules distributed evenly throughout the cell. 2nd. Bodies twice to thrice the size of a leucocyte containing similar granules of pigment, but arranged round clear spaces. 3rd. Pigmented bodies showing amœboid movement. 4th. Amœboid bodies containing large masses of pigment. These differ from the bodies described above in the character of the pigment, which is collected in large masses instead of fine rounded granules, and are probably the phagocytes on whose scavenging properties Carter lays so much stress. It is possible that all these forms are merely stages of the same body.

Dr. Prout did not detect pigmented crescents, spheres, or flagellated organisms. The intra-corpuscular forms were present before the paroxysm, and while the temperature was rising, and usually disappeared under treatment; while the pigmented forms were found at all stages, but persisted for a considerable time after the attack had ceased. In one case the whole of the bodies were found; in one there were rods, clear spots, and pigmented bodies; in one, rods, vacuoles, and pigmented bodies; in two, vacuoles and tadpole bodies; in three, vacuoles only; and in two, pigmented bodies only.

I am unable to identify most of the appearances described by Dr. Prout with the appearances which I consider to be characteristic of the parasites observed by me at Sierra Leone. I miss in his description the ring-shaped parasite which I found so universal in my cases. The larger pigmented bodies described by him, and shown in his drawings, will be generally, I believe, considered to be pigment-bearing leucocytes. As so little has yet been

written on the parasite of West African fevers, I have considered it advisable to give this *résumé* of the observations recorded by Dr. Prout, so that those who are specially interested in the subject may have an opportunity of referring to his original paper.

The following eleven cases are selected so as to illustrate the usual course of the fever in its relation to the parasite. In all the observations the blood was taken from the finger. I never saw any unpigmented forms free in the blood.

CASE 1.—Private B—, admitted to hospital on January 23rd, 1896, complaining of having suffered from fever since the 20th. Temperature on admission 103° F.

The blood examined at noon contained a number of free crescents. There was no movement in the crescents or their pigment. There was about a dozen in one specimen. Many of the crescents were elongated and narrow, nearly twice the size of a red cell. There were also minute unpigmented parasites in the red cells, similar to those seen in other specimens. There was a good deal of free pigment in the blood. At 5 p.m. temp. 101° F. Crescents still present in the blood. The patient received 5 grains of calomel, and later 5 grains of antifebrin, and two 15-grain doses of quinine.

January 24th.—Morning temperature normal. Patient feels better. Blood still contained crescents, but they are less numerous than on the previous day. One oval young form which was tinged externally with hæmoglobin. No evidence of spore formation. Movements of pigment visible in the crescents. Numerous pigmented leucocytes and a good deal of free pigment. Evening temp. 99° F.

25th.—Morning temperature normal. Patient feels quite well. Examined specimens of blood, one taken yesterday evening and one this morning. Crescents present in both, probably more numerous in the former. One crescent contained two separate bodies, one deeply pigmented, and the other having one or two minute dots.

At one time they appeared to unite, but in the end no special change occurred. There were a few unpigmented parasites and numerous pigmented leucocytes. Evening temperature normal.

26th.—Morning temperature normal. Crescents still present in the blood. No unpigmented parasites. Evening temperature normal.

27th.—Temperature normal. Appearances the same as yesterday.

28th.—Temperature normal. Appearances the same as yesterday.

February 1st.—Crescents still present. Patient discharged to duty.

In this case crescents were present in the blood without fever, and when fever appeared the unpigmented form was evident. While the crescents were present in this man's blood he was quite fit and well. No flagella appeared at any time.

CASE 2.—Private B—, admitted to hospital on the 24th January, 1896. On the 24th his evening temperature was 102.4° F.; 25th, morning temp. 104° F., evening 100.6° F.; on morning of 26th normal, evening 104° F.; on morning of 27th 105.8° F., evening 101° F.; morning of 28th normal. The blood examined on the morning of the 27th contained numerous minute unpigmented parasites, and on the morning of the 28th the same with crescents. Evening temperature of 28th 105° F.

29th.—Morning temp. 101° F. The blood contained unpigmented parasites and crescents.

30th.—Temperature normal. Nothing abnormal noticed except pigmented leucocytes.

31st.—Temperature normal. Pigmented leucocytes.

February 1st.—Temperature and microscopical appearances of the blood normal.

Patient readmitted on the 21st. Temperature at 12 noon 101° F., and at 6 p.m. 101° F.

22nd.—Morning temperature normal. The blood con-

tains numerous unpigmented parasites. No crescents. Some cells contained two parasites. One parasite had a dumb-bell shaped appearance. Evening temperature normal.

23rd.—Temperature at 6 a.m. 99° F., at 9 a.m. 101° F., and at 10.30 a.m. $103\cdot4$ F. The blood at 10.30 a.m. contained minute unpigmented parasites. In one cell in which I observed three parasites I saw one of them suddenly resolve itself into two separate bodies. The parasites less numerous to-day than yesterday. This patient refused to take quinine.

CASE 3.—Lance-Corporal C—, has just returned to Sierra Leone from the Ashanti expedition, arriving on March 2nd, 1896. After marching to Mount Auriol, a distance of two miles from the landing stage and about 800 feet above the sea, patient states he had a slight attack of fever the same night, which passed off in a few hours. He came to hospital on March 4th, stating that at 2 a.m. on the 4th he went to the rear, and on returning felt shaky and cold, for about half an hour had headache, afterwards became hot, and then reported himself sick. He says that he never had fever before, not even on the expedition. Morning temperature when admitted to hospital on the 4th, $103\cdot6^{\circ}$ F. Patient could retain nothing, and was put in a wet pack for half an hour, after which his temperature fell to 99° F. The blood was examined before wet packing, and was found to contain numerous unpigmented and a few pigmented parasites, mostly oval-shaped, with a ring of hæmoglobin (part of the red cell) surrounding them—the intra-corpuscular crescent form. The pigment was confined to the centre. Evening temp. 101° F.

March 5th.—Morning temperature normal. Blood contains numerous unpigmented parasites and numerous crescents, some large and others small, with a very little pigment. A few small, rounded, unpigmented bodies were evident in some of the crescents. Pigmented leuco-

cytes. Evening temp. 101.2° F. From this date the temperature remained normal.

8th.—Only crescents.

11th.—Blood examined before patient left hospital. Nothing abnormal, but only a cursory examination could be made.

This case is interesting from the very early appearance of crescents in the blood.

CASE 4.—Corporal T—, after having been in hospital for a week, and apparently sufficiently well to leave, was seized on the night of the 11th March, 1896, with another attack of fever.

March 12th.—Morning temperature 105° F. He was put in a wet pack, and temperature fell to 102° F. The blood contained numerous unpigmented parasites. These parasites were rounded in shape, and their diameter was one sixth of that of a red corpuscle. The colourless protoplasm was peripheral, the transparent centre transmitting the ordinary colour of the red corpuscle, giving the whole parasite a rounded shape. From their periphery small protoplasmic processes were actively projected and retracted; the parasite itself contracted and dilated, during the contraction the size being only about one half that of dilation. One oval-shaped pigmented parasite was observed; a narrow ring of hæmoglobin surrounded it and retained its colour.

Evening temperature 99° F. Blood contains a number of unpigmented parasites. No crescents or other forms were observed.

13th.—Morning temperature normal. The blood contains numerous pigmented and unpigmented parasites; the former contain one or two minute grains of pigment in the periphery, which continued to move for a considerable time. These grains of pigment moved round the periphery, and would suddenly be carried towards the centre of the parasite and back again to the periphery. The parasites were contracting and dilating. The pigmented

forms were about twice the size of the unpigmented. No crescents or oval forms were observed. Pigment-carrying leucocytes were seen.

A specimen was stained by allowing a small quantity of methylene blue to dry on the slide over which the drop of blood was placed. When examined, the central portion of the unpigmented parasites was stained blue, leaving the periphery quite clear. Evening temperature 99.8° F., and going up. The blood contained only a few unpigmented parasites. During the day the patient had taken 40 grains of hydrochlorate of quinine.

14th.—Temperature normal. No parasites visible in the specimens taken.

15th.—Morning temperature normal. Blood contains a few unpigmented parasites. Nothing else abnormal observed. Hydrochlorate of quinine continued in 15-grain doses twice daily.

21st.—Temperature has been normal since the 15th. To-day one parasite only observed, which was slowly throwing out its processes and having two grains of pigment. It was about twice the size of the unpigmented stage.

23rd.—Morning temperature 100° F. The blood contains a few unpigmented forms. Evening temperature 101° F. A few unpigmented forms and crescents.

24th.—Temperature normal. No parasites observed. Up to this time he continued to take 30 grains hydrochlorate of quinine daily. He left hospital on this date.

June 30th.—Returned to hospital with rigors. The blood contained numerous unpigmented forms. This patient had a great many admissions, and had a number of attacks during each admission.

CASE 5.—Private F—, March 16th, 1896. After he had been in hospital for some days it is noted that his temperature on the evening of this day was 102° F. The blood contained pigmented and unpigmented parasites of the size and form described in previous cases. Both

showed the characteristic staining with methylene blue when a small quantity of the stain was added to fresh blood.

17th.—Temperature normal. The blood contains a few unpigmented parasites. A small red cell contained an oval-shaped body with pigment, and between the pigment and the periphery two small spore-like bodies moved about.

18th.—Temperature normal. In a specimen of blood, to which solution of eosin had been added, numerous parasites were observed, and one slightly crescentic body, having a somewhat granular appearance, and tinged with hæmoglobin.

19th.—Temperature normal. The blood contained a few unpigmented parasites, but a prolonged examination was not made. The parasites in this case corresponded in appearance precisely with those observed in the previous cases. The man had the routine treatment with quinine all the time he was in hospital.

CASE 6.—Private E—admitted to hospital on the 27th March, 1896. Evening temp. $103\cdot2^{\circ}$ F., going up to 105° F. at 9 p.m. Five grains of calomel and 2 ounces of Mist. Senna Co.

March 28th.—7.30 a.m., temp. 104° F. At 10 a.m. 10 grains of antifebrin and 20 grains of quinine hydrochlorate. 10.30 a.m., examination of the blood. Unpigmented parasites and a spherical body surrounded by the remains of the red cell, with a small mass of pigment in the centre. One specimen was stained by adding methylene blue to the fresh blood, and a parasite observed which almost filled the red cell, and had taken the blue stain. There was a mass of pigment at one part of the periphery. In the unstained specimen, in addition to unpigmented forms there were red blood-cells containing small masses of pigment, the pigment masses consisting of light and dark portions. The clear part of the parasite pushed out pseudopodia-like processes. Whilst one was under observation the red cell gradually disappeared.

29th.—Temperature normal. Many red cells containing parasites spherical in form, and nearly filling the red corpuscle. In some the pigment lay towards the periphery, in others it was central. After being under observation for about an hour a spherical parasite became oval, and the central pigment grouped itself towards the centre, and could be observed moving for several hours. No free crescents were observed.

30th.—Morning temperature normal. One oval pigmented form and three unpigmented forms in one cell. No crescents.

CASE 7.—Private S—admitted to hospital April 1st, 1896, at 5 p.m., comatose. Seen by Surgeon-Captain Hall, who remained with him till 7.30 p.m. I saw him about 8.30 p.m., and found him quite comatose. On touching the conjunctiva there was at first a slight contraction of the orbicularis. Pupils somewhat contracted, no reaction to light; pulse 80, resp. 20. Temperature on admission 103° F., and in the evening 100° F. Breathing not stertorous. Up to 11.30 p.m. he received 60 grains of hydrochlorate of quinine hypodermically, 1 drachm of ether, and two enemata. The patient remained comatose during the night. Morning condition was the same.

April 2nd, morning.—The blood contained numerous pigmented and unpigmented parasites. No crescents visible, but I had not time to examine the peripheral blood very long. At about 1 p.m. there was a sudden quickening of pulse and respiration to 120 and 40. At 4.30 p.m. pulse 170, resp. 60. Still comatose, coma vigil. Temperature rose to 105° F.; condition remained the same till death at 12.40 a.m. on the 3rd.

Post-mortem at 9 a.m. All the organs congested, lymph on surface of brain. Liver weighed 5 pounds. Spleen slightly enlarged, soft and friable, of a dark plum-colour. Brain capillaries contained many pigmented parasites, the pigment being in one small block near the centre of the

parasite ; one sporulating form was observed. The affected red cells did not move. Blood from the liver and spleen contained much pigment. One pigmented parasite was observed in the blood from the spleen. I stained a specimen all night in hæmatoxylin, and next morning added a drop of eosin (1 in 1200). Several nuclei of the parasites took on a distinct purple stain, with one or two dark points in the clear part. In the centre of many of the parasites the eosin-stained red cell was visible, and each parasite had a ring of purple round it with one or two dark points.

This patient was in hospital a month before with an ordinary attack of malaria. He returned to duty in a few days. For two days previous to his last admission to hospital he had a slight attack of fever, but wishing to finish shooting in a rifle competition, he remained for about nine hours on each of these days at the rifle range, and very probably this prolonged exposure led to a fatal result. This case shows the necessity of absolute rest, however trivial the attack of fever may appear.

CASE 8.—Corporal K— admitted to hospital on May 19th, 1896 ; temp. 101° F. Patient states that fever began at 4 a.m. He has had many previous attacks of fever. The blood contained a number of unpigmented parasites, and crescents with the usual appearances, pigment being always in the centre except in one in which it was scattered. In some there was only a very small quantity of dark pigment without the appearance of the central body in which I usually observed the pigment grouped. Evening temperature normal.

May 20th.—Morning temperature normal. The blood contained several small round pigmented forms, in the centre of which the red cell was visible, and they every now and then contracted and expanded. The pigment was in active movement. Numerous crescents.

21st.—Temperature normal since first day. Crescents less numerous. No other forms.

25th. — Temperature normal. Patient discharged. Crescents still present. No other forms.

CASE 9.—Private F—, admitted on the evening of June 26th, 1896. Temp. $104\cdot6^{\circ}$ F.

June 27th.—Morning temp. $99\cdot2^{\circ}$ F. Evening temperature normal.

28th.—Morning temperature normal. Evening 101° F.

29th.—Temperature normal. He had twenty grains of quinine hydrochlorate daily during this time.

Microscopical examination of the blood.—Very many red cells much enlarged, paler than normal, and containing minute numerous pigment granules. A few contained what looked like definite amœboid bodies. There was distinct movement of the pigment granules. In the unstained specimens I did not observe any of the forms seen in the cases of pernicious malaria which I have described, but in the stained specimens I saw a small parasite in the red corpuscle with one very small pigment granule. This body resembled a form described in the pernicious cases.

This is the first case of tertian fever I have seen at Sierra Leone. Patient states he had several attacks of malaria in Jamaica. He came to the coast in the beginning of 1894, and it is legitimate to infer that the attack may have been a recurrence of the malaria acquired in Jamaica. (I make this remark with all deference.)

This man's case differed from the others in the accented rigors which ushered in the attack. It will be noted that while he had fever on the 26th and 28th, on the 27th he was free from fever, and the fever yielded rapidly to 20-grain doses of quinine daily. He was kept under observation for some time, and there was no relapse. These features agree with those which are characteristic of tertian ague, and the microscopical examination of the blood showed that the case was a true tertian. The comparatively large size of the parasite, still more the very much enlarged red cells, which to a great extent had lost their colour, sharply differentiated the microscopical

appearances from those which I have described in the pernicious cases, and harmonised completely with the description of the parasite of tertian fever, as described by Golgi and others.

CASE 10.—Private H— has been in hospital several months, suffering from heart disease, and has had several attacks of fever during that time. He states that the attack usually begins with shivering, but the attack this morning commenced without rigors. Temp. 99.4° F. Vomited once.

Examination of the blood shows many unpigmented forms and many crescents. An appearance which I observed in this case, and which I had never before observed, deserves special mention. A red cell was nearly filled with a parasite, the parasite consisting of clear protoplasm on the periphery, and in the interior a number of small irregular-shaped bodies in close contact, presenting a somewhat dendriform arrangement. While under observation this body, which was crescent-shaped, first enlarged, and then the small bodies which I have described were observed to oscillate and arrange themselves in a ring form, after which a bulging took place in the side of the crescent, and these bodies appeared to endeavour to become free, but apparently the wall of the crescent would not yield. The crescent swelled to about twice its original size, and the small bodies which it contained scattered themselves irregularly in its interior, and then ceased to oscillate. I do not wish to associate this solitary observation with any general law, but in connection with Grassi and Feletti's theory of the sporulation of the crescent body I have thought it well to place it on record. It was a solitary example seen during a series of observations of the crescent form, of which I must have watched some hundreds closely. At 2 p.m. temp. 102.8° F.; 6 p.m., temp. 99.4° F.; 9 p.m., normal. A number of crescents with a nipple-shaped projection were observed in the blood.

July 9th.—Fever began shortly after 10 a.m. Tempera-

ture at 4.30 p.m. 103.6° F. I observed an oval-shaped parasite with a pigment mass similar to that seen in crescents. It filled the red cell, from which the colour had entirely disappeared. It contained three distinct spores with a distinct nucleolus in each spore. The pigment was in clumps. Close to it, but not touching this body, was a patch of pigment to which a spore was adherent. This appearance is the nearest approach to what might be a crescent in sporulation which I observed. Several pigment-containing leucocytes were observed, the pigment granules being in motion.

11th.—2 p.m., temp. 102.2° F.; 6 p.m., temp. 101.4° F.; 9 p.m., temp. 101.4° F.

12th.—Temperature normal. Patient then passed out of my observation. During the attack quinine was given in the usual doses.

CASE 11.—Private M—, admitted to hospital July 10th, 1896, suffering from fever.

The blood contains pigmented and unpigmented parasites. The pigment is present in the form of one or two grains situated towards the periphery. The portion of the red cell present in the centre of the parasite sometimes consists of two parts. At 2 p.m. temperature 100.8° F.; at 6 p.m., 101.8° F.; at 9 p.m., 104° F.

11th.—Temperature at 9 a.m. 103° F. I stained a fresh specimen with Plehn's fluid, which caused the periphery of most of the parasites to become motionless, while the central mass appeared as a dark spot. The nucleolus became evident on staining some of them. In one unpigmented parasite there were two nucleoli deeply stained and moving most actively. The periphery of this parasite threw out processes, and it moved about the red cell, an appearance which I had not before observed. In the centre of many of the parasites three or four minute dark bodies moved rapidly. They were probably minute pigment granules. No crescents evident. A special appearance which was observed during this examination

should be noted. In a parasite which filled one half of the red cell, and which was oval and distinctly contoured; a block of pigment was situated at one end of the parasite, whilst a single solitary spore was observed at the other. The granules of pigment, although massed together, were in active movement. The appearance of the pigment and the shape of the parasite are very suggestive of a crescent formation (the *Laverania* of Grassi and Feletti). If this were the case, it would afford additional proof that the crescent form can produce a spore, but I do not insist on this interpretation. The appearance is not entirely inconsistent with the interpretation of a sporulating form of the pernicious parasite. Without insisting on any special interpretation, I simply put the fact on record. At 2 p.m. temperature 101.8° F.; at 6 p.m., 100.4° F.; at 9 p.m., 99.8° F.

12th.—Temperature at 7.45 a.m. 99.8° F.; at 10 a.m., 101.4° F.

13th.—Minute dark points no longer visible in the parasite. Few parasites visible. A parasite was seen throwing out processes on the blood-cell.

Of these 11 cases all were negroes, with the exception of Case 4, a white man.

If we exclude a case of tertian fever (the only one observed amongst about 400 cases), it will be seen that in the malarial fevers of Sierra Leone the only parasitic forms observed in the peripheral blood are a very small amœboid organism, usually ring-shaped, a slightly further advanced stage in which a little very fine pigment can be detected on the periphery, a further stage in which the pigment is massed towards the centre of the parasite, which has enlarged to about twice the original size (only observed a few times), and the crescent forms fully developed, and in the partially developed intra-corpuscular forms. In the amœboid and pigmented forms nuclear elements can be observed. Nuclear elements were not seen in the crescents, but a differentiated central portion in which the pigment

accumulates could be made out. In one case appearances were observed which could be explained by assuming the accuracy of the theory of Grassi and Feletti that the crescent body may form spores, but I do not desire to lay much weight on a solitary observation. In blood taken from a vein in the brain of a fatal case I observed a sporulating form in which both the central pigment and the spores were distinct. I never saw the so-called rosette form in the peripheral blood. I never observed the quartan forms described by Golgi, and only once the characteristic appearances of the tertian parasite of that observer.

In order to compare the parasites which I saw with the quartan and tertian forms of Golgi, I was obliged to get specimens containing these forms from Europe. Dr. Thin was kind enough, at my request, to send me preparations containing the tertian and quartan parasites. These were very distinct, and I was able to satisfy myself that no such appearances (always excepting the solitary case of tertian) were present in the cases which I examined. Is there anything in my description of this parasite which can be considered evidence that the parasite of malaria in Sierra Leone is a distinct species? I find that there is not. If my description and the drawings which accompany this paper are compared with the description and the drawings which illustrate the work by Marchiafava and Bignami, it will be seen that the Sierra Leone forms correspond in every essential particular with the parasites which those authors describe as being found in the so-called summer-autumn fevers of Southern Italy. The small amœboid ring-shaped forms and the small forms with very fine pigment find their exact countertypes in the descriptions of the Italian authors. The "ottonati" or brassy forms described by them I did not observe. This is the only particular in which my description appears to differ from theirs, and in this connection it may be noted that Thayer and Hewetson in describing the summer-autumn fevers at Baltimore also find many of the so-called brassy-red corpuscles.

As regards the ætiology I can add nothing to what has already been written on this subject.

Expeditions into the interior of Sierra Leone, which are generally limited to two months on account of the difficulties of transport, are followed by a large increase in the cases of malaria. After the regiment has returned to Sierra Leone, fever very soon attacks officers and men, more especially the former, and a fatal result is by no means rare.

Among the officers of the Sierra Leone Frontier Force, who have to spend most of their fifteen months' tour in the interior, the mortality is higher than is the case with the officers of the West India Regiment who serve for a year on the coast.

Mosquitoes are present before and during the rainy season. There are so few that mosquito nets are hardly necessary. Many of the officers are bitten by these mosquitoes, some rather severely, but I do not know of a single case having been followed by fever.

It may be interesting to state that I have found examination of the blood of value diagnostically in cases brought into hospital comatose. There are cases in which it is important to eliminate other causes of coma, such as apoplexy and alcoholic poisoning. Persistent headache and cases of subacute rheumatism have been generally returned as malarial, but I have found by microscopic examination of the blood that many of these cases, particularly the latter, are frequently not caused by malaria. In all cases of malaria I found the parasite, and therefore its absence may be held as conclusive of the case being non-malarial.

For treatment I shall simply refer to the routine administration by most medical officers on the coast, of calomel, antipyretics, and quinine. Wet packing is extremely useful in cases of persistent vomiting. I obtained no benefit from boric acid in 30 grains thrice daily, or Liquor Hydrarg. Perchlor. in drachm doses thrice daily. Arsenic appeared to be of service in one case of malarial fever which lasted

for several weeks. I did not employ any of these three drugs for a lengthened period.

Quinine should be given early and in large doses (15—20 grains), repeated every two to three hours until the temperature is normal.

Absolute rest is necessary in every case, however trivial the symptoms may appear.

(For report of the discussion on this paper, see 'Proceedings of the Royal Medical and Chirurgical Society,' Third Series, vol. ix, p. 99.)

DESCRIPTION OF PLATE XXIII.

Figs. 1—22 represent the appearances observed in the fresh blood.

Fig. 1.—Small ring-shaped parasite. Fig. 2.—Four such parasites attacking one red corpuscle. Figs. 3, 4, and 5 show the parasite in the active motile stage. Figs. 6, 7, and 8 show the parasite in the stage in which pigment formation begins. Figs. 1—8 are blood taken from the finger.

Figs. 9—12 represent red blood-corpuscles from a drop of blood taken from the surface of the brain in a fatal case, about eight hours after death. Central pigment can be seen in all four. In Fig. 10 it appears divided into two portions. In Fig. 12 five separate spores can be counted.

Figs. 13—22 represent various appearances shown by the crescent form. In Fig. 13 the crescent nearly fills the red corpuscle. Fig. 14 shows a round crescent nearly filled with pigment, the collection of pigment being unusually large. Fig. 14*a* represents the parasite shown in 14, after it had undergone change, the pigment collecting in the centre. This change occurred whilst the parasite was under observation. Fig. 15.—A crescent with central pigment, filling about half the red corpuscle. Fig. 16.—Larger crescent than 15, almost filling the red corpuscle. Figs. 17, 18, and 19 show various types of the crescent parasite.

Figs. 20, 20*a*, 20*b*, 20*c*.—Transformations of the parasite observed under the microscope, which is described at p. 231. The first form of the parasite observed is shown in Fig. 20; the other three figures show the gradual transformation which took place. Fig. 21 represents what the author considers to be a form suggestive of spore formation in a crescent (see p. 232). There was no doubt as to the crescent nature of this body, and the pigment blocks and spore-like forms were separate and distinct in its interior. Close to the crescent, adhering to some pigment, was a free spore.





Fig. 22 shows a small crescent body inside a red corpuscle, with a pigment block at one end, and a small circular body with a central point at the other end—suggestive of a spore. This spore-like body was identical in appearance with the three spore-like bodies shown in Fig. 21.

Figs. 23—31 represent appearances in stained preparations.

These preparations were stained at Sierra Leone, and were drawn by Mrs. Danielsson.

Fig. 23 shows the minute nucleolar body. Fig. 24 shows a similar nucleolar body on the periphery. Fig. 25.—No separate nucleolar body was observed. Fig. 26.—The deeply stained nucleolar body is surrounded by an uncoloured portion, whilst the periphery is stained blue. Figs. 27, 28, and 29 show similar phases. They were observed in one preparation in the same field of the microscope adjoining each other. In Figs. 26, 27, and 29 there were two nucleoli in each parasite. In Figs. 26, 27, and 29 the colourless space surrounding the nucleolus, which has been described by Mannaberg as the nucleus, is very distinctly observed. Fig. 30 shows the young form of the parasite in a case in which there were many crescents in the blood. Fig. 31.—Fully developed crescent form from same preparation as Fig. 30.

In none of the parasites represented from 23 to 30 had the development reached the stage of pigment formation.

Figs. 1—22 represent as near as possible the size of the elements drawn as seen by $\frac{1}{12}$ oil immersion lens and Zeiss No. 8 eye-piece. Figs. 23—29 were purposely drawn to a similar scale.

